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USING STATED PREFERENCES (SP) TO ANALYZE THE SERVICE QUALITY OF PUBLIC TRANSPORT

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USING STATED PREFERENCES (SP) TO ANALYZE THE SERVICE QUALITY OF PUBLIC TRANSPORT

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ABSTRACT

In order to determine the level of satisfaction of the public transport services, the passengers jointly evaluate the various attributes that represent the different aspects of the level of service. From a methodological viewpoint this means finding the weighting that individuals use to evaluate those attributes within what is considered as the level of global satisfaction or utility. In this paper we obtain indicators that permit the aggregate measurement of the quality of the public transport bus services on Gran Canaria in Spain. The analysis focuses on obtaining the travellers' preferences using Stated Preferences (SP) designs, that face the individual to the choice between the current bus service and a hypothetical service defined, from a combination of the most relevant variables. With this information multinomial logit models are estimated that permit us to obtain a linear representation of the utility function, from which a measure of the global quality of the service is obtained. Results of the analysis demonstrate that passengers have clearly different behaviour, depending on whether they are urban or interurban users; this is especially relevant in their perception of certain attributes such as service frequency, and to some extent the willingness to pay relative to the components of total travelling time.

KEY WORDS: Public Transport, Quality of Service, Willingness to Pay, Stated Preferences.

1. INTRODUCTION

Measuring the quality of public services is currently one of the major challenges for economic analysis; this is due to the importance of its results both for companies that provide these services and for the supervisory public administration. One relevant variable in evaluating public transport is the level of services offered. Typically, the demand side is measured in terms of passengers or passengers per kilometre, and the supply side using the vehicles per kilometre. As with the other grouped output indicators, these aggregate measures implicitly assume the quality of service to be homogeneous. However, in practice, passengers evaluate the transport services in various ways, using criteria that are not associated with the level of transport usage. For example, no relationship between the level of satisfaction of the passengers and the number of passengers per kilometre has been demonstrated.

Despite the maximization of the number of passengers per kilometre being used as an indicator to represent the maximization of social welfare and passenger accessibility, there is hardly any research that analyzes how the passengers perceive the quality of the services. Among the available papers, attention should be drawn to the pioneering article by Ortúzar et al. (1977), where the most relevant attributes for public transport users were identified as being the level of perceived importance for these aforementioned variables. More recently, Professor David Hensher at the University of Sydney oversaw research papers that developed a methodology specifically designed for constructing quality indicators for the public bus transport services in Australia; the starting point was the designs for stated preferences (For a more detailed reference see: Hensher 2000, Hensher and Prioni 2002, Hensher and Houghton 2004, Hensher 2002a, Hensher 2002b, Hensher and Houghton 2002 and Hensher et al, 2003). Other studies based on the methodology proposed by Cook and Kress (1988) aim to obtain the relative weightings of the attributes that determine the level of service, by analyzing the ranking of the attributes; see Garrido and Ortúzar 1994.

This paper has twin objectives. On the one hand, to obtain indicators that permit the aggregate measurement of the quality of the public transport bus services on Gran Canaria in Spain; and on the other, to obtain the willingness to pay to improve the service's main defining factors. In order to determine the level of satisfaction of the public transport services, the passengers jointly evaluate the various attributes that represent the different aspects of the level of service; for example travel time, frequency, comfort, punctuality, information at the bus stops etc. Some of these attributes such as the service frequency are perceived positively, whereas others like waiting time have a negative connotation. The idea is to find the weighting that individuals use to evaluate each attribute within what is considered as the level of global satisfaction or utility. In this way, it is possible to understand the contribution of each basic attribute to the global measurement of quality. The analysis focuses on obtaining the preferences using Stated Preferences (SP) designs that face the individual the choice between the current bus service and a hypothetical service, obtained from a combination of changes in the most relevant attributes. With this information, discrete models of choice are estimated¹ in order to obtain the weights for the (parameters θ_i) of the attributes (X_i) in the utility function, which is generally represented by a linear-in-the-parameter expression:

$$U = \theta_1 X_1 + \theta_2 X_2 + \theta_3 X_3 + \theta_4 X_4 + \theta_5 X_5 + \theta_6 X_6 + \dots \quad (1)$$

Once the parameters have been estimated, the service quality indicators (SQI) for each route, company, group of passengers etc. are obtained by applying the previous expression to the

¹ See McFadden (1981), Domencich and McFadden (1975) and Ortúzar and Willumsen (2001), in order to consult the theoretical foundations of the discrete choice models.

average value of the attributes; the levels achieved in the current trip for a specific group must also be taken into account. For example, the SQI for route j is given by the expression:

$$SQ_j = \theta_1 \bar{X}_1^j + \theta_2 \bar{X}_2^j + \theta_3 \bar{X}_3^j + \theta_4 \bar{X}_4^j + \theta_5 \bar{X}_5^j + \theta_6 \bar{X}_6^j + \dots \quad (2)$$

Where $\bar{X}_i^j = \frac{1}{Q_j} \sum_{q=1}^{Q_j} X_{iq}^j$, X_{iq}^j is the value of the attribute i in the current trip for the individual q who travels route j and Q_j is the number of passengers in the sample for route j .

2. DATA

The public transport services in Gran Canaria (Spain) are provided by two companies: Guaguas Municipales² which is in charge urban transport, and Global which is responsible for interurban transport. The latter company was formed by a merger between Salcai and Utinsa which were respectively responsible for providing services in the south and the north of the island. The analysis is based on the information provided by 551 urban and 1052 interurban passengers. Beforehand, in order to determine the sample, a classification of the different routes using cluster analysis was carried out. Afterwards, one representative route for each group was chosen, and then passengers on that route were selected randomly at different stops. The sample size for each route was proportional to the total number of passengers.

The surveys were carried out by a group of fully trained interviewers who used laptop computers³. The questionnaire was completed by urban and interurban transport users and consisted of three blocks of questions. The first brought together information about the journey. The second block was composed of a set of stated preferences that made the individuals choose between the current service⁴ and a hypothetical service that was designed using a combination of the most relevant attributes. The third and final part of the questionnaire collected socioeconomic information at both, the household and the individual level; this group of questions was strategically placed at the end of the interview. Had the order been different, then the confidential nature of many of these questions may have produced a negative reaction and less information about the service might have been obtained.

The final set of attributes was decided using the information obtained after several focus group reunions, which were attended by a wide range of representatives from companies and the island's transport administration. The attributes and levels used in the SP experiment are shown in Table 1⁵. With the aim of making the experiment realistic, the levels of the variables: travel time, prices, frequency and access time were adapted to the real perceived values for the individual in the current service. The number of attributes was very high, and could give rise to the individual having difficulties evaluating all of them simultaneously; so in each application there were two sets of choices, and the most relevant attributes of each one remained. Each set consisted of six hypothetical choices that were randomly selected by the

² In the Canary Islands the word "guagua" is used to refer to a bus.

³ To construct the experiments we used the WinMint program created by Rand Europe, formerly known as The Hague Consulting Group.

⁴ The objective was to analyze the level of perceived global utility achieved by the current public bus transport service.

⁵ The experiment was constructed with an orthogonal design, which only permitted the estimation of the main effects. More recently, it has been demonstrated that the use of efficient designs, based on minimizing the D-error, give rise to more robust estimations of the parameters for a given sample size; see Bliemer and Rose (2006) for further details. Nevertheless, as the sample size increases, the differences in the standard deviations of the estimators obtained by the efficient and orthogonal designs decrease.

computer, and the individual had to choose between the current and the alternative service⁶. With urban transport the scenarios for the first set were based on the variations in the levels of the following attributes: travel time, price, frequency, access time, comfort and information. The second set included: travel time, price, frequency, the driver, cleanliness and the bus shelter. For the designed interurban transport application the first set included: travel time, price, frequency, punctuality, access time and comfort. The attributes included in the second set were: travel time, price, information, the driver, cleanliness and the bus shelter.

3. MODELS AND RESULTS

The analysis of passenger preferences is based on the exploitation of the databases of stated preferences that come from the two sets that were presented in the questionnaire. The estimation methodology with mixed data, as proposed by Bradley and Daly (1997), permits databases with different characteristics to be combined. This way it is possible to estimate the marginal effect of each of the attributes included in the experiment. Figure 1 shows the structure of the artificial tree that was proposed in the estimation with mixed data.

The combined use of different databases to estimate modal choice models is based on the hypothesis that the difference between the stochastic errors of the utilities can be represented in terms of its variances in accordance with the expression (Ben-Akiva and Morikawa, 1990):

$$\sigma_{\varepsilon}^2 = \mu^2 \sigma_{\eta}^2 \quad (3)$$

Where μ is an unknown parameter and ε and η are the error terms for the utilities of the two respective SP databases. In order to be able to combine the two databases, the following utility functions are set out for an alternative j that is present in both of the databases:

$$\begin{aligned} \mu U_j^{PD_1} &= \mu(V_j^{PD_1} + \eta_j) = \mu(\theta X_j^{PD_1} + \omega Z_j^{PD_1} + \eta_j) \\ U_j^{PD_2} &= V_j^{PD_2} + \varepsilon_j = \theta X_j^{PD_2} + \alpha Y_j^{PD_2} + \varepsilon_j \end{aligned} \quad (4)$$

Where θ , α and ω are parameters to be estimated, $X_j^{PD_1}$ and $X_j^{PD_2}$ are common attributes to the two databases, and $Z_j^{PD_1}$ and $Y_j^{PD_2}$ are attributes that are held in only one of the databases.

A prior analysis, based on the separate estimation of the two SP sets, permitted us to verify that the parameters of the common attributes varied in the same proportion, in accordance with the recommendations by Louviere et al (2000).

For the urban and interurban transport Multinomial Logit (MNL1 and MNL2) type models and Mixed Logit (ML1) were estimated by using the artificial tree structure that was proposed in the methodology for estimations with mixed data. All the variables were considered to be linear, except for the travel costs which were divided by the expenditure rate (g); this was defined as $R/(T - W_h)$, where R is the individuals income, T is the total time for the reference period and W_h are the working hours⁷. In this way the effect of income upon the decisions of the passengers is included, since the marginal utility of income (ζ), obtained as minus the marginal utility and travel cost $(-\partial V / \partial C)$, is different for each person⁸. As each individual

⁶ In recent research either modular arithmetics has been used to divide the design into balanced blocks, or efficient designs whereby the researcher predetermines the number of situations of choice to be employed.

⁷ In this study one week is considered as the reference period, and also the per *capita* indicator for the family income.

⁸ Other studies have demonstrated the existence of systematic variation in tastes in the context of urban transport; they consider the interactions of socioeconomic variables with the attributes of the level of service; see Ortúzar et al. (1977) and Espino et al. (2006). However, in this case the specification has not been set out, since the

responds to six different choice situations in each of the set, the effect of the inertia and the correlation among the responses of a specific individual are analyzed. Model MNL2 has an inertia variable (I) included, which groups together the effects that previous decisions have upon the current choice. This variable is specified in the utility of the current option⁹ and is defined as the number of times an individual chose the current option in the context of previous choices (Adamowicz, 1994). For example:

| <u>Choice situation</u> | <u>Chosen Option</u> | <u>Inertia (Current Option 2)</u> |
|-------------------------|----------------------|-----------------------------------|
| 1 | 1 | 0 |
| 2 | 2 | 0 |
| 3 | 2 | 1 |
| 4 | 1 | 2 |
| 5 | 2 | 2 |
| 6 | 2 | 3 |

Besides the model ML1 studying the inertia, the effect of the correlation among the responses for a given individual is also analyzed. For this a Panel Mixed Logit specification with fixed parameters has been considered, but with an error component (μ_{iq}) in each set that follows a normal distribution with zero mean. This way the utility would be:

$$U_{1q} = \sum_k \theta_k X_{1kq} + \varepsilon_{1q}$$

$$U_{2q} = \sum_k \theta_k X_{2kq} + \mu_{2q} + \varepsilon_{2q} \quad \mu_{2q} \rightarrow N(0, \sigma_1)$$

$$U_{3q} = \sum_k \theta_k X_{3kq} + \varepsilon_{3q}$$

$$U_{4q} = \sum_k \theta_k X_{4kq} + \mu_{4q} + \varepsilon_{4q} \quad \mu_{4q} \rightarrow N(0, \sigma_2)$$

Where X_{ikq} represents the vector of attributes for the alternative i , θ_k are parameters to be estimated and ε_{iq} are iid Gumbel variables.

Tables 2 and 3 show the estimation results for urban and interurban transport, respectively. For urban transport, in Table 2, 17 of the 6624 observations corresponded to inconsistent responses; i.e. the worst alternative in all attributes was chosen. These were eliminated from the sample, which resulted in a total of 6607 valid observations. All the parameters were estimated with the correct sign and were significant at the 95% confidence level, with the exception of the information variable¹⁰. This means that the effect of having information with maps and timetables at bus stops versus only providing information about the route and/or itinerary was negligible for urban transport users. However, the effect of passing from a zero level of information to a level two, that is to say electronic panels, maps and timetables, was much greater and this variable had an important significance.

In all the cases the discrete variables were categorized into three levels. The parameter obtained for the level two resulted positive and larger than that obtained for level one; this indicates that the level two is perceived as having greater utility than level one. The parameter for level one is also in all cases positive, which indicates that the aforementioned level of the variable produces greater utility than level zero does; the latter is considered as the base for the specification of the dummy variable in the utility specification. These results are totally consistent with the stated preferences approach of the experiment.

paper's main objective is to obtain a measurement of the global perception of each attribute. Nevertheless, the variation analysis of both systematic and random tastes remains pending for future research.

⁹ Alternative two in the first set and alternative four in second one.

¹⁰ This variable was eliminated from the specification of model ML1 due to an erroneous sign.

The inertia variable was very significant and with a positive sign in model MNL2, which shows evidence that the current choice is influenced by the decisions taken by the individual in the situations presented in previous choices; this indicates inertia behaviour towards the use of the current service. Nonetheless, model ML1 shows also the existence of correlation among the responses of the same individual in each one of the sets, and the inertia ceases to be significant at a 95% level of confidence. This indicates that in model MNL2 the effect of the inertia is confounded with the correlation, so we consider that ML1 is the statistically superior model.

For urban journeys access time at the bus stop generally produces less disutility than travel time. This may be explained because the access times are not high (normally less than ten minutes), the majority of people walk to the stop and the weather is generally pleasant. However, the effect of time between two services (frequency), which is related to the waiting time at the bus stop, is more negatively perceived than travel time. The qualitative attributes that have a greater importance on the utility are level 2 of comfort, the attitude of the driver and cleanliness.

Specific constants are specified in the utilities of alternatives 1 and 3. Except for the set 1 in MNL2 model, both have a negative sign. This result demonstrates that in general there is a preference for the current service, when the effect of the experiment's considered attributes is zero.

In the case of interurban transport (see Table 3), all the parameters were estimated with the correct sign and were significant in all the models at the 95% confidence level, with the exception of the presence of bus shelters and access time. With respect to the latter variable, it is worth mentioning that it only turned out to be significant, at the 90% confidence level in MNL1; and its effect affected only to those passengers that walked to the bus stop and lived in Las Palmas. In all other cases, the contrary effect was observed with a positive sign. This result, apparently counter intuitive, can be explained because within the sample there was a significant percentage of individuals that travelled to the bus stop by car. For these people the bus stop access time could result more pleasant than the in-vehicle travel time. In reality, some of these trips should be considered as multimodal car-bus journeys. If we consider that for these people the total duration of the journey is fixed, the individuals would prefer the options of greater access time since more time in the car would involve less time in the bus; that is to say that the access time is a better option than the travel time. This behaviour could give rise to the estimation of access time with a positive sign.

Compared to the urban journeys, the negative effect of time between the two services is somewhat lower than the travel time. This is due to passengers on the interurban routes being more accustomed to consulting the timetable, and of being capable of better adjusting their arrival times at the bus stop. However, timetable delays have a negative effect that is six times greater than the travel time.

With respect to the three defined discrete levels for qualitative variables, the estimations follow the same model as urban transport; that is to say the estimated parameter for level one was superior to that for level two, which is consistent with the experiment. In terms of the importance of the previously mentioned variables, in level two we would like to draw attention to the comfort, followed by driver's attitude, information and cleanliness. In contrast to urban transport, the inertia variable was significant in both models, and according to model ML1 there was even correlation in the results of the same individual. The specific constant had a positive sign in set one, the variables included are: time, frequency cost, punctuality, access time and comfort. All this demonstrates that there are aspects that have not been measured, but which make individuals show their preference for the alternative rather than the

current service. As with urban transport, the specification of the ML1 model was statistically superior.

3.1 Obtaining service quality indicators in public transport

After obtaining the estimations for the best model, a hybrid utility function was constructed by scaling (i.e. multiplying by the factor μ) those parameters of the set one attributes that were not common to both datasets (Louviere et al, 2000). Indicators of the quality of service were obtained for each passenger by evaluating the aforementioned utility function in the current service¹¹. The quality of the global urban and interurban transport service was given by the average of all the individual utilities.

In Figure 2 it is possible to appreciate the relative importance that each of the attributes has upon the construction of the global quality indicator. In both cases it can be seen that the attributes whose effect is negative, that is travel time, walking time, frequency and delay, are more important than the others. This is especially important for urban transport, where these attributes have a weighting of 80%; The time between two services (or service frequency), which in this type of trips is associated to the waiting time at the bus stop is especially important. This attribute has a much lower weighting for interurban journeys, which means that the disutility produced by this variable is significantly lower. It is important to note that although the frequency of service may be worse in some interurban routes, the estimated parameter for this variable is almost three times less. With respect to the other variables, attention should be drawn to the importance of comfort and the driver's attitude in interurban journeys in level 2.

Figure 3 shows the sample distribution of the SQI for the urban and interurban journeys. In both cases the effect on the perception of the current quality of transport (black line) has been analyzed. The application of consistent policies in the obtaining of gradual discounts in terms of the distance covered has been analyzed but only for interurban journeys (red line), and finally the 30% travel cost reduction (blue line) has been analyzed for both cases. The application of this last policy, for the interurban case, significantly increases the proportion of passengers who have a perception of superior quality to a given value, and is represented by the area beneath the line and to the right of the aforementioned value. Moreover, it can be seen that this effect is much more frequent with individuals that have a worse perception of the quality of service.

3.2 Willingness to pay measures

The willingness to pay (WTP) measures express, in monetary units, the changes produced in the utility due to the changes in the attributes. For continuous attributes, these are represented as the quotient of marginal utility for the corresponding attribute and the marginal utility of the travel cost; that is to say $\frac{\partial V / \partial q_k}{\partial V / \partial C}$. When dealing with discrete variables, the WTP to pay in order to improve the variable from one given level to another, for example from zero to one, is equal to: $WTP_{q_{ij}} = \frac{V^1 - V^0}{\lambda}$; where λ is the marginal utility of income, obtained as minus the marginal utility of travel cost.

¹¹The study also provided representative indicators of the quality of service for each researched route by evaluating the utility function of the average value for each attribute for the passengers on the route, in accordance with the current service. These results are not available in this article but interested readers can request them to us.

In the two applications the cost of the journey divided by the rate of expenditure is specified. In this way the effect of income upon the decisions of the passengers is taken into account, something that is not possible when the specification of the travel cost adopts the linear form. This specification gives rise to different value of the willingness to pay among the passengers, since the marginal utility of income $-\frac{\theta_{C/g}}{g}$ is different for each person. A common practice in

these cases is to apply the sample enumeration method, in order to obtain a representative measure through the average of the willingness to pay for all the individuals in the sample; see Ortúzar and Willumsen (2001). However, when the distribution of the WTP is asymmetrical (that is, when the mean and the median of the distribution do not coincide), then using the mean as the representative measure for the WTP may result in an unsatisfactory policy for the majority of the individuals. For example, Figure 4 shows an asymmetrical distribution of the WTP for travel time savings that is skewed to the left; i.e. the median (Me) is less than the mean (\bar{x}) of the distribution. If for each unit of time saved passengers were charged the price $p = \bar{x}$, then $P(WTP \geq p) \leq 0.5$. This would mean that over 50% of the passengers would be dissatisfied with this policy, since $P(WTP < p) > 0.5$; that is to say that their willingness to pay would be lower than p . As such, charging a higher than median price would not fulfil the objective of satisfying at least 50% of the individuals. A similar analysis could be carried out, if the distribution is skewed to the right.

In the case of discrete variables, for example those categorized into three levels, we spread the distribution of the willingnesses to pay from level 0 to level 1 and from level 0 to level 2. In the example shown in Figure 5 both distributions are skewed to the left, moreover $Me_1 < Me_2$. If by improving the level of service in this attribute the price $p > Me_2$ was charged, then over 50% of individuals would be dissatisfied even when offered the highest level of quality; i.e. level 2. Note that $P(WTP_{0-2} > p) < 0.5$. If $Me_1 < p \leq Me_2$, over 50% of the passengers would be satisfied, but only if the company offered the highest level of quality. However, the majority of the passengers would be dissatisfied if they received level 1 quality, in this case $P(WTP_{0-2} > p) > 0.5$ but $P(WTP_{0-1} > p) < 0.5$. If $p \leq Me_1$, the majority of the passengers would be happy, even if they received level 1 quality.

This analysis reiterates that the shape of the distribution of the willingness to pay should be borne in mind when these measures are used for policy purposes.

Table 4 shows the values for the willingness to pay for improvements in quality of service in urban and interurban transport for the specification of the best model (ML1). It is pertinent to point out that in all the cases analyzed the distributions were skewed to the left and, that in accordance with the previous discussion, to indicate the mean and median values of the distributions.

The results of the analysis demonstrate that public transport users in Gran Canaria show clearly differentiated behaviour, depending on whether they use urban or interurban transport. By taking the mean reference value into account, for urban transport users the greater willingness to pay is for saving waiting time between the two services (2.14 euros/hour), followed by travel time (2.12 euros/hour) and access time (1.12 euros/hour). However, for interurban transport, the greater willingness to pay is to reduce delays (7.93 euros/hour), which is more than double what individuals are prepared to pay for saving travel time (2.73 euros/hour). On the other hand, the willingness to pay to save waiting time is not as significant as for urban routes.

In terms of qualitative variables, for urban routes the greater willingness to pay to pass to the optimal level of quality, that is to pass from level 0 to level 2, is given by improving comfort (0.36 euros per trip to be seated during all the journey), the driver's attitude (0.33 euros per trip for pleasant treatment and smooth driving) and cleanliness (0.29 euros per trip so that the bus is clean). Passengers are prepared to pay 0.16 euros per trip for electronic panel to be placed at the stops, but only 0.08 euros for bus shelters. Willingness to pay to improve the qualitative aspects were in general greater for interurban routes than for urban ones, in particular the willingness to pay for improving comfort (3.47 euros to be seated during the whole route) and for improving the driver's attitude (0.80 euros per trip for receiving pleasant treatment and smooth driving).

4. CONCLUSIONS

Providing a public transport system that is capable of satisfying the growing mobility needs of citizens currently constitutes an irrefutable need for the economic development of any society. Despite this, there is great controversy over what the future role of public transport should be, and over how public administration should be involved in satisfying the real needs of demand versus other possible priorities.

By observing the tendency in most cities worldwide, we can certainly see that public transport has not done well in assuring its long term sustainability and that too much trust has been placed in the help provided by both local and national governments. In recent decades institutional reforms focused on reducing productive inefficiency due to inadequate state intervention have also taken place. This new regulation shows the possibility of improving intervention, in order to achieve a public transport policy that benefits citizens as a whole. Thus, some net welfare gains can be achieved that the traditional schemes would otherwise not produce, and these gains may be reflected in the prices. This is because the productive inefficiencies, which are the consequence of inadequate public involvement, are reduced. Alternatively, other rules that are compatible with incentives may be followed, in order to get transport companies to follow the signals emitted by the users.

The majority of public transport companies have either their own productivity indicators or quality parameters for some of their services. These indicators are usually based on the calculation of an index, such as the number of vehicle kilometres per hour worked by the drivers or the number of passengers per kilometre for each worker. The service quality parameters are usually based on the measurements of some attributes that are considered important, such as travel time, the average frequency of the services, the average delay, the average age of the buses that serve a route etc. Despite the internal utility of these self evaluation processes, in the majority of the cases they are not valid for formulating either transport policies or for specific actions to improve user welfare. This is due to the fact that the studies on quality must be based not only on setting certain standards within the industry with spatial or temporary criteria for a series of processes, but also on the degree of relative importance that the combined attributes have upon the level of passenger satisfaction. For this reason, the public authorities, be they regulators or providers, must go about establishing levels of quality that maximize user utility.

The starting point of the method applied in this paper is the need to study the users' demands, and to confirm how much they are prepared to pay for them. The aim is to obtain a monetary measure for the benefits and social costs associated with the implementation, or otherwise, of specific courses of action. Additionally, given the ever present existence of budgetary restrictions, the monetary valuation of user preferences offers an objective guide to how to prioritize different performances.

The use of stated preference designs has enabled us to estimate, with a reasonable margin of error, the monetary value that transport users assign to certain service variables. These values constitute an essential input in the welfare analysis of transport policies. This way, it is possible to socially evaluate the distinct performances of public transport services in cities, and determine which policies have better results.

When the social costs of carrying out a transport policy measure are lower than the social benefits, we have an objective criterion that guarantees transport users will improve in terms of welfare. Nonetheless, this does not mean that all the policies whose net balance is positive should automatically be carried out, since budgetary restrictions or the need to account for the benefits and costs for non-transport users may establish different priorities.

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Table 1. Attributes and levels used in the SP experiment

| | Attribute | Level 0 | Level 1 | Level 2 |
|----|--|---|---|---|
| 1 | Travel time | T+20% | T | T-20% |
| 2 | Price | P+20% | P | P-20% |
| 3 | Time between two services (Frequency) | F+25% | F | F-25% |
| 4 | Access time to bus stops | Ta + 5 min. | Ta | Ta - 5 min. |
| 5 | Punctuality (only in interurban transport) | 10 min. delay | 5 min. delay | On time |
| 6 | Comfort | Standing during all the journey | Standing in part of the journey | Seated during all the journey |
| 7 | Information at the bus stop (urban transport) | Itinerary maps | Maps and timetable | Electronic panels, maps and timetables, |
| 8 | Information at the bus stop (interurban transport) | None | Maps and timetable | Electronic panels, maps and timetables, |
| 9 | Shelter | NO | YES | — |
| 10 | Driver behaviour | Unpleasant treatment and aggressive driving | Pleasant treatment and aggressive driving | Pleasant treatment and smooth driving |
| 11 | Cleanliness | Poor | Normal | Good |

Keys: T: actual travel time; P: actual price; F: actual frequency; .Ta: Actual access time

Table 2. Urban Transport. Estimation results

| Attributes | MNL1 | | MNL2 | | ML1 | |
|---------------------------------|----------------|------------------------|--------------------------|------------------------|-----------|--------|
| | parameter | t-test | parameter | t-test | parameter | t-test |
| <i>Travel time (T)</i> | θ_T | -0.1337 (-8.4) | -0.1480 (-8.86) | -0.1510 (-8.38) | | |
| <i>Travel cost/g (C/g)</i> | $\theta_{C/g}$ | -4.2110 (-9.1) | -4.4100 (-9.09) | -4.7600 (-8.97) | | |
| <i>Frequency (F)</i> | θ_F | -0.1402 (-11.3) | -0.1230 (-10.34) | -0.1530 (-10.73) | | |
| <i>Access time (TA)</i> | θ_{TA} | -0.0717 (-5.2) | -0.0646 (-4.84) | -0.0754 (-4.95) | | |
| <i>Comfort Level 1(C1)</i> | θ_{C1} | 0.6285 (5.0) | 0.6350 (5.41) | 0.7730 (5.06) | | |
| <i>Comfort Level 2(C2)</i> | θ_{C2} | 1.2180 (7.5) | 1.0900 (7.59) | 1.4400 (7.35) | | |
| <i>Information Level 1 (I1)</i> | θ_{I1} | 0.0225 (0.3) | 0.0499 (0.8) | - | - | |
| <i>Information Level 2 (I2)</i> | θ_{I2} | 0.5581 (5.4) | 0.5220 (5.55) | 0.6470 (5.26) | | |
| <i>Driver level 1 (CH1)</i> | θ_{CH1} | 0.4215 (4.0) | 0.3420 (3.24) | 0.4870 (3.93) | | |
| <i>Driver level 2 (CH2)</i> | θ_{CH2} | 1.2120 (10.5) | 1.1400 (9.81) | 1.4300 (9.37) | | |
| <i>Cleanliness level 1 (L1)</i> | θ_{L1} | 0.5133 (5.2) | 0.5080 (5.16) | 0.5820 (4.57) | | |
| <i>Cleanliness level 2 (L2)</i> | θ_{L2} | 1.0020 (9.7) | 1.0700 (10.35) | 1.2300 (9.52) | | |
| <i>Shelter (M)</i> | θ_M | 0.3168 (3.7) | 0.2350 (2.72) | 0.3270 (2.94) | | |
| <i>Constant alt 1 PD1</i> | C_1 | -0.1372 (-2.8) | 0.1540 (2.6) | -0.0727 (-0.88) | | |
| <i>Constant alt 1 PD2</i> | C_2 | -0.5824 (-7.1) | -0.1530 (-1.43) | -0.5310 (-3.73) | | |
| <i>Inertia (I)</i> | θ_I | - | 0.2270 (7.28) | 0.0650 (1.57) | | |
| <i>Scale factor SP</i> | μ | 1.0610 (8.9) [0.5]* | 1.1400 (9.13) [1.12]* | 1.0600 (8.8) [0.5]* | | |
| <i>Sigma 1</i> | σ_1 | - | - | 0.7640 (6.44) | | |
| <i>Sigma 2</i> | σ_2 | - | - | 0.9160 (8.16) | | |
| <i>l*(0)</i> | | -4579.6234 | -4579.6234 | -4579.6234 | | |
| <i>l*(θ)</i> | | -3043.1248 | -3010.512 | -2981.454 | | |
| <i>Observations</i> | | 6607 | 6607 | 6607 | | |

* test t with respect to $\mu=1$

Table 3. Interurban Transport. Estimation results

| Atributos | | MNL1 | | MNL2 | | ML1 | |
|--|--------------------|-----------|-------------------|------------|--------------------|------------|--------------------|
| | | parameter | t-test | parameter | t-test | parameter | t-test |
| <i>Travel time (T)</i> | θ_T | -0.0794 | (-9.8) | -0.0484 | (-6.74) | -0.0848 | (-9.29) |
| <i>Travel cost/g (C/g)</i> | $\theta_{C/g}$ | -1.8250 | (-12.4) | -1.3900 | (-9.26) | -1.9500 | (-11.46) |
| <i>Frequency (F)</i> | θ_F | -0.0598 | (-5.6) | -0.0270 | (-6.15) | -0.0501 | (-6.16) |
| <i>Delay (R)</i> | θ_R | -0.4889 | (-6.0) | -0.2450 | (-7.8) | -0.4420 | (-6.98) |
| <i>Walking access time in LP (TA*W*LP)</i> | $\theta_{TA*W*LP}$ | -0.0798 | (-1.7) | -0.0495 | (-2.2) | -0.1100 | (-2.89) |
| <i>Comfort Level 1(C1)</i> | θ_{C1} | 2.2740 | (3.8) | 1.2900 | (4.94) | 1.6500 | (3.76) |
| <i>Comfort Level 2(C2)</i> | θ_{C2} | 7.8750 | (5.6) | 3.4900 | (7.27) | 6.4600 | (6.45) |
| <i>Information Level 1 (I1)</i> | θ_{I1} | 0.7072 | (8.8) | 0.6020 | (7.35) | 0.7140 | (6.9) |
| <i>Information Level 2 (I2)</i> | θ_{I2} | 1.2370 | (11.7) | 1.1700 | (10.88) | 1.3300 | (10.76) |
| <i>Driver level 1 (CH1)</i> | θ_{CH1} | 0.3107 | (2.8) | 0.8430 | (7.22) | 0.6070 | (4.57) |
| <i>Driver level 2 (CH2)</i> | θ_{CH2} | 1.4000 | (13.4) | 1.9200 | (17.32) | 1.8700 | (14.95) |
| <i>Cleanliness level 1 (L1)</i> | θ_{L1} | 0.2844 | (3.1) | 0.2550 | (2.75) | 0.3890 | (3.46) |
| <i>Cleanliness level 2 (L2)</i> | θ_{L2} | 0.8159 | (9.0) | 0.7650 | (8.38) | 1.0600 | (9.01) |
| <i>Shelter (M)</i> | θ_M | 0.0704 | (1.0) | 0.1090 | (1.55) | 0.0962 | (1.03) |
| <i>Constant alt 1 PD1</i> | C_1 | 1.8530 | (4.6) | 1.1000 | (7.26) | 1.7100 | (5.44) |
| <i>Constant alt 1 PD2</i> | C_2 | -0.8243 | (-10.2) | -0.1310 | (-1.36) | -0.6050 | (-4.68) |
| <i>South corridor (S)</i> | θ_S | 0.2955 | (4.3) | 0.1750 | (2.98) | 0.3100 | (3.46) |
| <i>Inertia (I)</i> | θ_I | - | - | 0.3330 | (13.27) | 0.1550 | (4.64) |
| <i>Scale factor SP</i> | μ | 0.3815 | (5.9) [-9.51]* | 0.8120 | (7.75) [-1.79]* | 0.5570 | (6.77) [-5.38]* |
| <i>Sigma 1</i> | σ_1 | - | - | | | 2.0600 | (6.3) |
| <i>Sigma 2</i> | σ_2 | - | - | | | 0.9180 | (11.35) |
| $l^*(0)$ | | | | -8747.5174 | | -8747.5174 | |
| $l^*(\theta)$ | | | | -5131.140 | | -4950.601 | |
| <i>Observations</i> | | | | 12620 | | 12620 | |

* test t with respect to $\mu=1$

Tabla 4. Willingness to pay measures

| Attributes | Interurban transport | | Urban transport | |
|--|-----------------------------|--------|------------------------|--------|
| | Mean | Median | Mean | Median |
| Travel time (€/hour) | 2.73 | 2.36 | 2.12 | 1.93 |
| Access time (€/hour) | 2.11 | 1.71 | 1.12 | 1.02 |
| Time between two services (€/hour) | 0.90 | 0.78 | 2.14 | 1.96 |
| Delay time (€/hour) | 7.93 | 6.86 | - | - |
| Comfort From level 0 to level 1 (€) | 0.49 | 0.43 | 0.19 | 0.17 |
| Comfort From level 0 to level 2 (€) | 3.47 | 3.00 | 0.36 | 0.33 |
| Information From level 0 to level 1 (€) | 0.38 | 0.33 | - | - |
| Information From level 0 to level 2 (€) | 0.71 | 0.62 | 0.16 | 0.15 |
| Driver From level 0 to level 1 (€) | 0.33 | 0.28 | 0.11 | 0.10 |
| Driver From level 0 to level 2 (€) | 1.00 | 0.87 | 0.33 | 0.31 |
| Cleanliness From level 0 to level 1 (€) | 0.21 | 0.18 | 0.14 | 0.12 |
| Cleanliness From level 0 to level 2 (€) | 0.57 | 0.49 | 0.29 | 0.26 |
| Shelter (€) | 0.05 | 0.04 | 0.08 | 0.07 |

Figure 1. Artificial tree structure. Estimation with mixed data

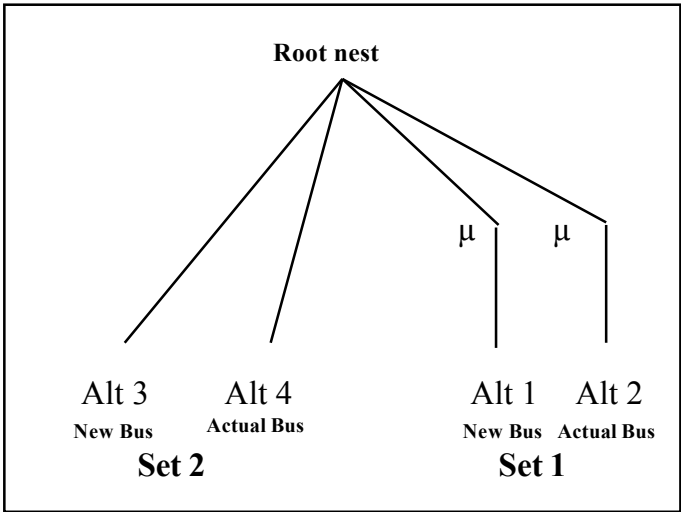


Figure 2. Relative importance of all the dimensions considered in the service quality.

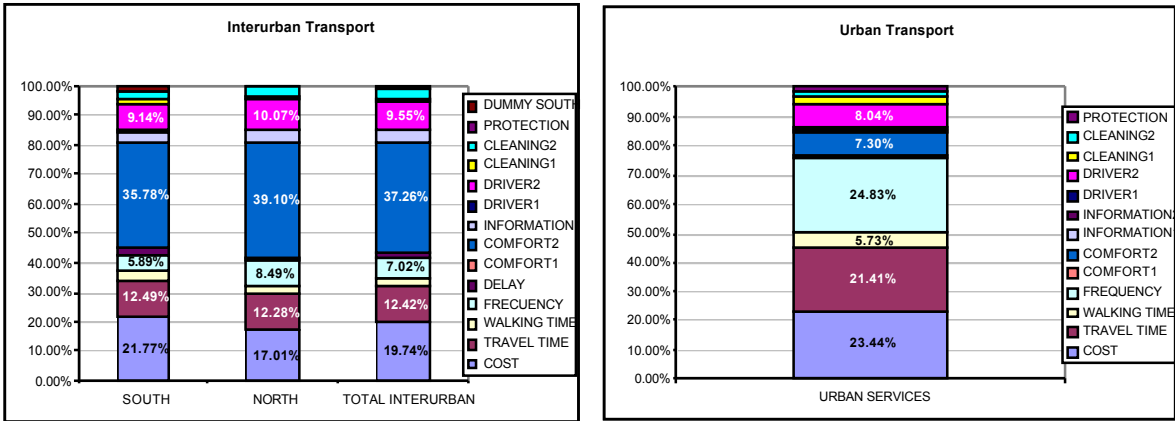


Figure 3. Density distribution of the service quality index

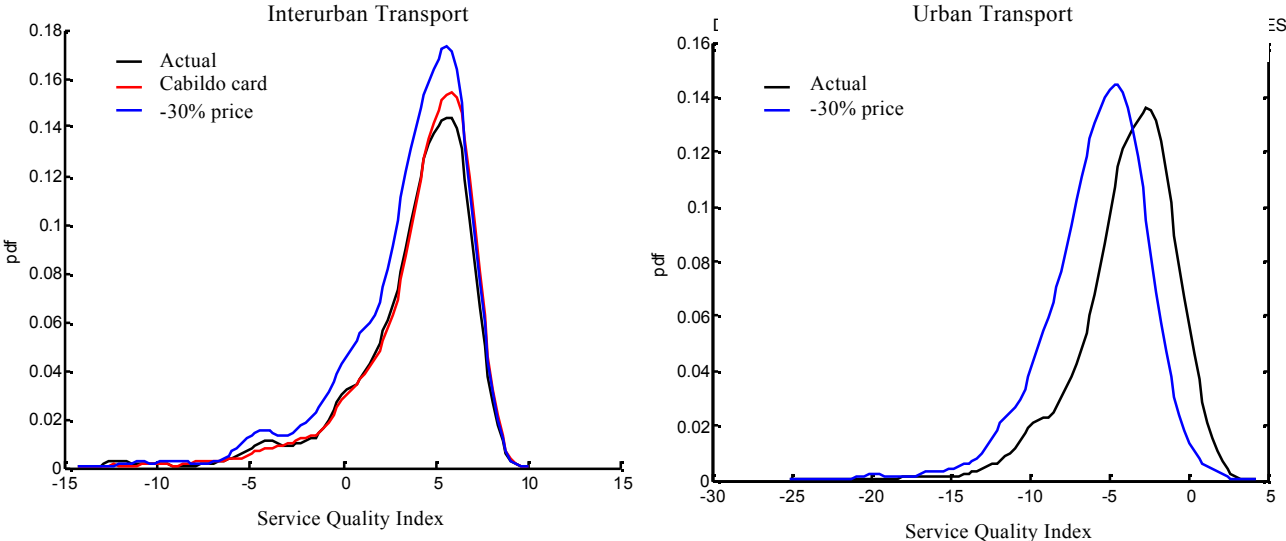


Figure 4. Asymmetric distribution of WTP for a continuous variable

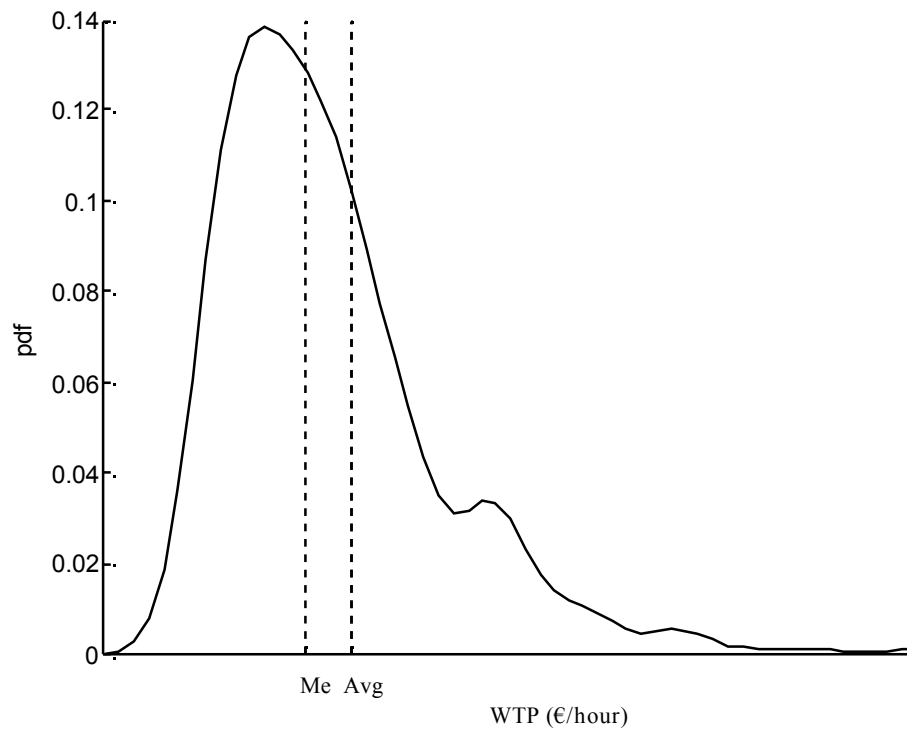


Figure 5. Asymmetric distribution of WTP for a discrete variable

